

**CLAIMS**

1. A method for use in transcribing a musical sound signal to musical notes, comprising the steps of:
  - 5 (a) producing note markers, indicative of the beginnings and ends of notes in said sound signal; and
  - (b) detecting the pitch values of notes marked by said note markers.
- 10 2. A method according to claim 1, further comprising detecting portions of said sound signal that can be deemed to be silences.
3. A method according to claim 2, wherein the note marker producing step uses the results of the silence detecting step.
- 15 4. A method according to claim 2 or 3, wherein the pitch value detecting step uses the results of the silence detecting step in addition to the results of the note marker producing step.
- 20 5. A method of producing note markers, indicative of the beginnings and endings of notes in a musical sound signal, comprising the steps of:
  - (a) extracting an envelope of said sound signal;
  - (b) differentiating said envelope to compute a gradient function; and
  - (c) extracting note markers from said gradient function, indicative of
- 25 the beginnings and ends of notes in said sound signal.
6. A method according to claim 5, wherein the process of envelope extraction comprises the steps of:
  - (i) performing full-wave rectification on said sound signal; and
  - (ii) low-pass filtering the output of the full-wave rectification.

7. A method according to claim 5 or 6, wherein the process of differentiation comprises the steps of:
- (i) determining the gradient of said envelope; and
  - (ii) low-pass filtering said gradient.
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8. A method according to any one of claims 5 to 7, wherein the process of note markers extraction comprises the steps of:
- (i) removing small gradients from said gradient function;
  - (ii) extracting turning points of the attack and decay of remaining
  - 10 gradients;
  - (iii) removing unwanted attacks and decays; and
  - (iv) registering remaining attacks and decays as said note markers.
9. A method according to any one of claims 5 to 8, wherein any one or
- 15 more of the envelope extraction step, the differentiation step and the note marker extraction step is performed based on a determination of silences in the musical sound signal.
10. A method for detecting the pitch values of notes in a musical sound
- 20 signal, comprising the steps of:
- (a) isolating notes in the sound signal;
  - (b) dividing said notes into one or more groups of blocks;
  - (c) deriving pitch values of said blocks; and
  - (d) deriving the pitch values of said notes by means of clustering on
  - 25 said pitch values of said blocks.
11. A method according to claim 10, wherein the process of isolating notes uses note markers to do so.

12. A method according to claim 10 or 11, wherein the blocks in a group are of equal length.
13. A method according to any one of claims 10 to 12, wherein each group  
5 contains the same number of blocks.
14. A method according to any one of claims 10 to 13, wherein the process of deriving the pitch values comprises applying k-mean clustering on the block pitch values.  
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15. A method according to any one of claims 10 to 14, further comprising the step (e) of rounding the detected pitch values of the notes to the nearest note values.
- 15 16. A method according to any one of claims 10 to 15, wherein the note isolating step is performed based on a determination of silences in the musical sound signal.
17. A method according to any one of claims 10 to 16, wherein the note  
20 isolating step is performed based on a determination of note markers in the musical sound signal.
18. A method according to claim 17, wherein the note markers are determined using the method of any one of claims 5 to 9.  
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19. A method according to any one of claims 1 to 4, wherein the note marker producing step is performed according to the method of any one of claims 5 to 9.

20. A method according to any one of claims 1 to 4 and 19, wherein the pitch value detecting step is performed according to the method of any one of claims 14 to 23.
- 5 21. A method according to any one of claims 1 to 4, 19 and 20, further comprising the step of extracting notes from said pitch values to create note descriptors.
- 10 22. A method of identifying pieces of music, comprising the steps of:  
receiving a musical sound signal imitative of a piece of music;  
transcribing said musical sound signal to a series of musical notes and timings using the method of any one of claims 1 to 4 and 19 to 21;  
comparing said series of musical notes and timings with series of notes and timings of pieces of music in a database; and  
15 identifying the piece of music deemed most similar by this comparison.
23. A method according to claim 22, further comprising the step of retrieving the identified piece of music.
- 20 24. A method according to claim 22 or 23, wherein the pieces of music in said database include songs and the related series of notes and timings include those of the vocal portions of the songs.
- 25 25. A method according to any one of the preceding claims, wherein the musical sound signal is digitised.
26. A method according to any one of the preceding claims, wherein the musical sound signal is an audio signal of a sound produced by a person.

27. A method according to claim 26, wherein the sound comprises one or more of the group of: humming, singing and whistling at least a portion of a piece of music.
- 5 28. Apparatus for use in use in transcribing a musical sound signal to musical notes, operable according to the method of any one of the preceding claims.
29. Apparatus for use in transcribing a musical sound signal to musical  
10 notes, comprising:
- (a) note marker producing means for producing note markers, indicative of the beginnings and ends of notes in said sound signal; and
  - (b) pitch value detecting means for detecting the pitch values of notes  
15 marked by said note markers.
30. Apparatus according to claim 29, further comprising silence detecting means for detecting silences in said sound signal.
- 20 31. Apparatus according to claim 30, wherein the note marker producing means uses the results from the silence detecting means for producing note markers.
- 25 32. Apparatus according to claim 30 or 31, wherein the pitch value detecting means uses the results of the silence detecting means in addition to the results of the note marker producing means for detecting the pitch values.

33. Apparatus for producing note markers, indicative of the beginnings and endings of notes in a musical sound signal, comprising:
- (a) envelope extracting means for extracting an envelope of said sound signal;
  - 5 (b) differentiating means for differentiating said envelope to compute a gradient function; and
  - (c) note marker extracting means for extracting note markers from said gradient function, indicative of the beginnings and ends of notes in said sound signal.
- 10 34. Apparatus according to claim 33, wherein said envelope extracting means comprises:
- (i) rectification means for performing full-wave rectification on said sound signal; and
  - 15 (ii) filtering means for low-pass filtering the output of the rectification means.
35. Apparatus according to claim 33 or 34, wherein the differentiation means comprises:
- 20 (i) gradient determining means for determining the gradient of said envelope; and
  - (ii) gradient filtering means for low-pass filtering said gradient.
- 25 36. Apparatus according to any one of claims 33 to 35, wherein the note marker extracting means comprises:
- (i) gradient removing means for removing small gradients from said gradient function;
  - (ii) attack and decay extracting means for extracting turning points of the attack and decay of remaining gradients;

(iii) attack and decay removing means for removing unwanted attacks and decays; and

(iv) attack and decay registering means for registering remaining attacks and decays as said note markers.

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37. Apparatus according to any one of claims 33 to 36, wherein any one or more of the envelope extraction means, the differentiation means and the note marker extraction means performs its operation based on a determination of silences in the musical sound signal.

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38. Apparatus for detecting the pitch values of notes in a musical sound signal, comprising:

(a) note isolating means for isolating notes in the sound signal;

(b) pitch value dividing means for dividing said notes into one or more groups of blocks;

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(c) block pitch value deriving means for deriving pitch values of said blocks; and

(c) note pitch value deriving means for deriving the pitch values of said notes by means of clustering on said pitch values of said blocks.

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39. Apparatus according to claim 38, wherein said note isolating means uses note markers to isolate notes.

40. Apparatus according to claim 38 or 39, wherein the blocks in a group are of equal length.

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41. Apparatus according to any one of claims 38 to 40, wherein each group contains the same number of blocks.

42. Apparatus according to any one of claims 38 to 41, wherein the note pitch value deriving means is operable to apply k-mean clustering on the block pitch values.
- 5 43. Apparatus according to any one of claims 38 to 42, further comprising rounding means for rounding the detected pitch values of the notes to the nearest note values.
- 10 44. Apparatus according to any one of claims 38 to 43, wherein the note isolating means operates based on a determination of silences in the musical sound signal.
- 15 45. Apparatus according to any one of claims 38 to 43, wherein the note isolating means operates based on a determination of note markers in the musical sound signal.
46. Apparatus according to claim 45, wherein the note markers are determined using the apparatus of any one of claims 33 to 37.
- 20 47. Apparatus according to any one of claims 29 to 32, wherein the note marker producing means comprises apparatus according to any one of claims 33 to 37.
- 25 48. Apparatus according to any one of claims 29 to 32 and 47, wherein the pitch value detecting means comprises apparatus according to any one of claims 38 to 47.
- 30 49. Apparatus according to any one of claims 29 to 42, 47 and 48, further comprising note extracting means for extracting notes from said pitch values to create note descriptors.



50. Apparatus for identifying pieces of music, comprising:  
receiving means for receiving a musical sound signal imitative of a  
piece of music;  
5 transcribing means for transcribing said musical sound signal to a  
series of musical notes and timings using the apparatus of any one of  
claims 29 to 32 and 47 to 49;  
music comparing means for comparing said series of musical notes  
and timings with series of notes and timings of pieces of music in a  
10 database; and  
identifying means for identifying the piece of music deemed most  
similar by this comparison.
51. Apparatus according to claim 50, further comprising retrieving means  
15 for retrieving the identified piece of music.
52. Apparatus according to claim 50 or 51, wherein the pieces of music in  
said database include songs and the related series of notes and timings  
include those of the vocal portions of the songs.  
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53. Apparatus according to any one of claims 28 to 52, operable to  
process a digital musical sound signal.
54. Apparatus according to any one of claims 28 to 53, operable to  
25 process a musical sound signal being an audio signal of a sound produced  
by a person.
55. Apparatus according to claim 54, wherein the sound comprises one or  
more of the group of: humming, singing and whistling at least a portion of a  
30 piece of music.

56. Software which, when loaded, is operable according to the method of any one of claims 1 to 28.
- 5 57. A memory device containing software according to claim 56.
58. A computer having loaded therein, software according to claim 56.